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The cooperative Breeding Bird Survey in Canada, 1989–91

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Introduction

The Breeding Bird Survey (BBS) has grown from an experimental survey in two U.S. states in 1965 to the most widespread and widely accepted means of monitoring breeding bird numbers in the United States and Canada. For most land birds, and for many noncolonial water birds and shorebirds, it is the only survey that extends across the continent (east to west) and for which 20+ years of comparable data are available. The data in most areas are collected by volunteers, although financial assistance or professional involvement may be necessary to ensure continuing coverage in peripheral areas, including northern Canada. Reports on the BBS in Canada through 1980 (listed by Erskine et al. 1990) focused on year-to-year changes in numbers of breeding birds, while seeking satisfactory ways of assessing long-term trends. More recently, the route-regression approach (Geissler and Noon 1981) has become the usual means of calculating long-term trends from BBS data, despite ongoing uncertainty over statistical weighting and handling of changes over time spans shorter than that of the full data series.

Efforts were made recently to ensure that Canadian volunteers receive published summaries of year-to-year and long-term trends from the BBS before the next field season, as they did in 1970–80. Although the 1988 report (Erskine et al. 1990) appeared 10 months late, preliminary tables covering 1989 and 1990 results (AJE, unpubl. data) were circulated in May 1990 and 1991, respectively; data for those years were received too late for analysis and publication to be completed in time. The present report covers 1991, with 1989 and 1990 treated in less detail, using modified weighting with the same statistical program as in 1988.

The authors' roles were as follows: EH and CD handled the national coordination of the BBS in Canada during 1990 and 1991, respectively; BTC modified the statistical weighting process (except area weighting), developed new data selection and output programs, and oversaw the running of the analyses; and AJE carried out the route screening and updating of the area weighting and drafted the text.

Methods

Data collection and assembly

The BBS procedures for data collection were unchanged from those of former years (see Erskine 1978; Robbins et al. 1986). Canadian data were assembled at the National Wildlife Research Centre in Hull, Quebec, where computer data entry was done in 1990 and 1991 before merging with the U.S. data files. This ensured that Canadian data were available for processing at the National Wildlife Research Centre by November, rather than in January or later, as was the case with the 1988 and 1989 data.

Data screening

The screening system determines which surveys are included in analyses and how they are grouped for analysis. As the identification and counting of birds can be influenced substantially by several factors, the observations from different years on the same route were screened to evaluate if the data collection provided values that were comparable. The series of observations over years for one route were divided, when necessary, into subroutes.

A subroute is defined as a set of surveys on the same route that were run under similar conditions. The set of conditions used to define a subroute were as follows:

(1) all surveys in a subroute were run by the same observer;

(2) all surveys in a subroute were in a span of 19 or fewer calendar days (this is a change from the 1988 analysis, which used a span of 14 days);

(3) all surveys in a subroute were run under similar and acceptable weather conditions: generally, winds should not exceed force 3 (Beaufort scale), and drizzle or rain should be avoided; on the Prairies, force 4 winds (which are frequent) are usually acceptable; stronger winds or precipitation may be tolerated, if only of brief duration. Starting in 1991, observers were asked to record the weather conditions after every 10 stops, thus six times per survey (instead of only twice as in the past), which should help future assessment of this factor.

In addition, any surveys run outside the allowable dates (28 May through 7 July) and those that started more than one hour after the prescribed time or that finished after 11:00 (local time) were excluded from the analyses.

The regions used to group comparable routes for analysis were unchanged (Fig. 1).

Area weighting

No change was made in area weighting, which considers the numbers of routes in a degree-block of latitude/longitude, the proportion of land area in each degree-block, and whether or not adjacent degree-blocks are represented by comparable surveys.

Data analysis

The observed counts were transformed using the equation

$$z = \log(y + 0.23)$$

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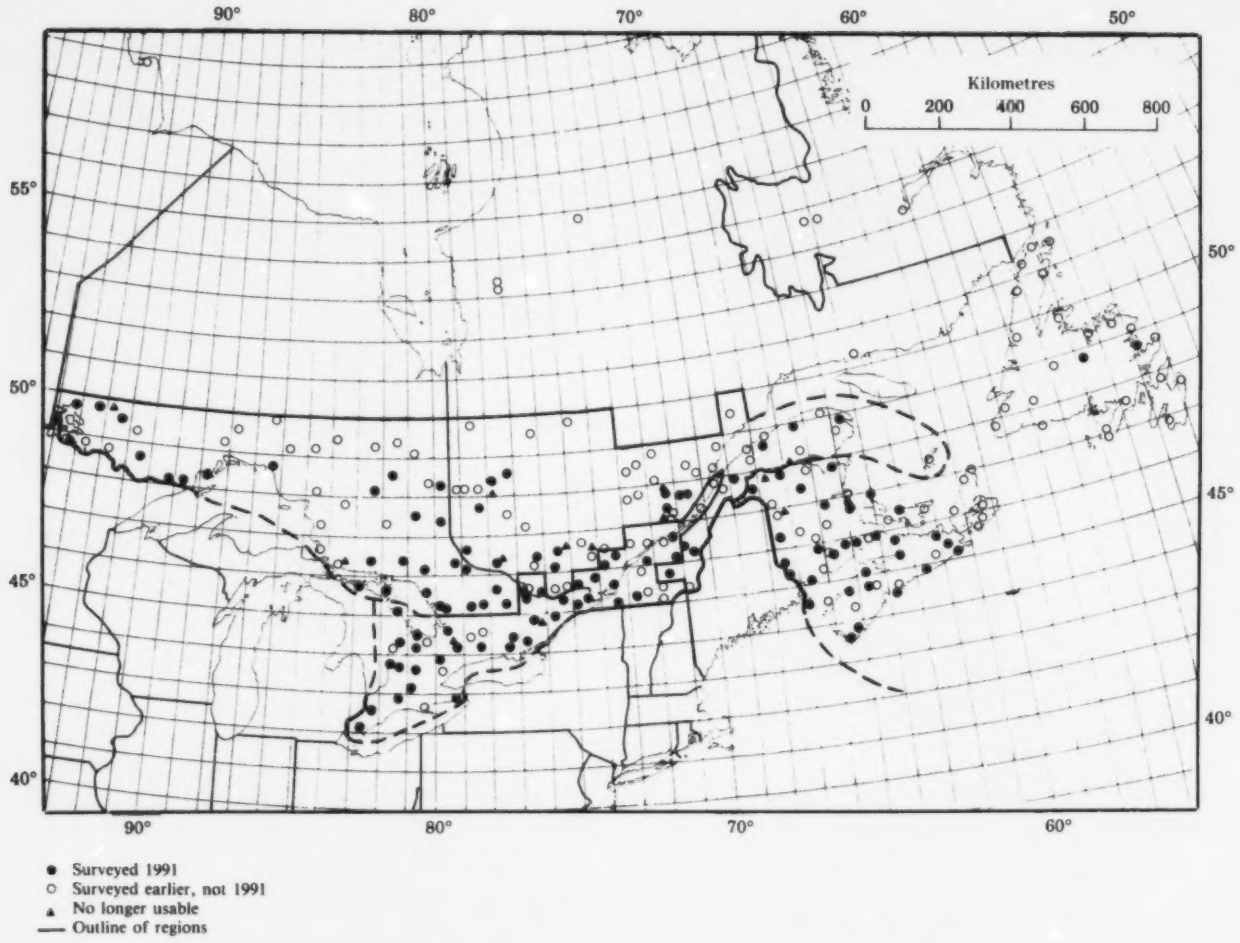
Figure 1
Distribution of Breeding Bird Survey routes as surveyed in 1966–91 in (a) Newfoundland, the Maritime provinces, and southern and central Ontario and Quebec, and (b) the southern and central Prairie provinces, British Columbia, and the territories

(a)



where y denotes the original count. The justification for this transformation is given in Collins and Wendt (1989). For each route, a linear model of the form

$$z_{ij} = A_i + Bx_{ij} + e_{ij}$$

was fitted to the transformed counts, where z_{ij} denotes the j-th observation on subroute i, A_i denotes the intercept for subroute i, B denotes the trend over time for the route, x_{ij} denotes the year for the j-th observation on subroute i, and e_{ij} denotes the random error about the model.

The overall estimate of trend for the biogeographic regions is a weighted average of the estimated trends for individual routes. The weights were a product of three factors:

(1) a measure of the precision of the trend estimate for the route, given by

$$\sum_i \sum_j (x_{ij} - \bar{x}_{i.})^2$$

where $\bar{x}_{i.} = \sum_j x_{ij}/m_i$ and m_i denotes the number of observations in subroute i;

(2) a measure of the population density, given by

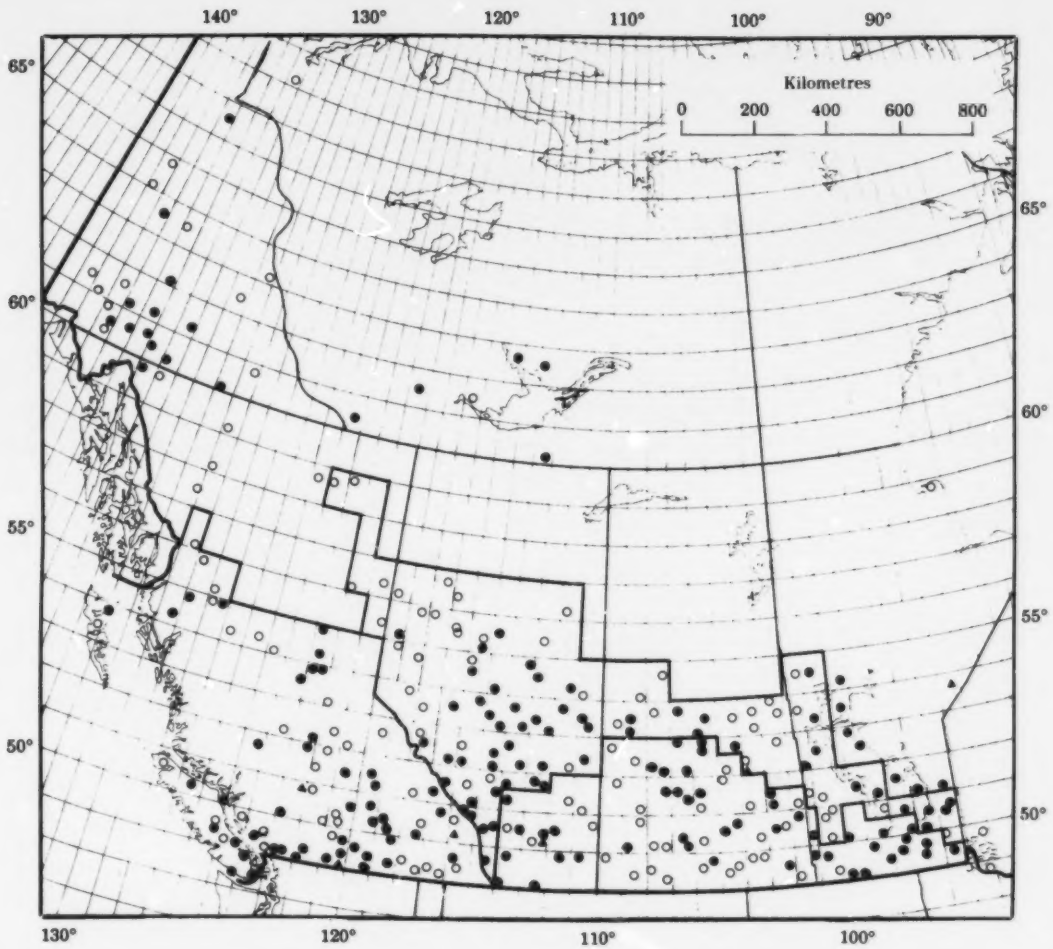
$$\exp[\sum_i (a_i + bx_c)/n]$$

where a_i and b are the estimates of the parameters of the model, x_c is the midyear of the time period, and n is the number of subroutes; and

(3) an area weighting term, as described above.

This analysis is different from that done by Collins and Wendt (1989) and Erskine et al. (1990): in the earlier analyses, a trend estimate was made for each subroute, and a weighted average of the subroute trends was used to estimate the overall trend; in this analysis, trends are estimated at the route level. The previous analysis was found to give undue weight to subroutes that were run only for a few

(b)



years. This occurred when the observations for a subroute were taken well away from the midyear of the time period, and hence the estimated population density was extrapolated well outside the range of observed values when deriving the weight for the route. The current scheme of estimating a route trend reduces these problems and provides more realistic trends.

Analyses were done for 81–92 species in each of the six major biogeographic regions outlined in Figure 1: the Maritime provinces (MAR), central Ontario and central Quebec (COQ), southern Ontario and southern Quebec (SOQ), the southern Prairie provinces (PRA), the central Prairie provinces (CPP), and southern British Columbia (SBC). The three-letter abbreviations for regions given here are used hereafter in the text. All species with large enough samples (i.e., species averaging 40+ individuals per year in one region) were analyzed, but long-term trends were not presented for species found on fewer than 15 routes in all years combined.

Results

Coverage

BBS routes surveyed to date are shown in Figure 1. Numbers of routes surveyed in 1984–91 and total numbers of routes available are presented in Table 1. The totals shown are of surveys for which data were received in Canadian files by November 1991.

Analyses

The total number of species analyzed was 172. Data are presented here for all species analyzed in one or more regions, except gulls and most waterfowl.

The splitting, since 1973, of the earlier "Yellow-bellied Sapsucker" and "Traill's Flycatcher" into two (or more) species posed problems. For the sapsuckers, we chose to combine for analysis all the three (closely related) forms in SBC; only one form of sapsucker occurred in the other regions. For the flycatchers, counts since 1973 showed that Willow Flycatchers comprised only 1, 3, 6, and 6% of the totals for these and Alder Flycatchers in MAR, COQ, PRA, and CPP, respectively; we judged it was acceptable to treat the combined (Traill's Flycatcher) data before 1973 in these regions as representing Alder Flycatcher trends only. In SOQ, Willow Flycatchers comprised 34% of the totals since 1973. As the earlier data could not be sorted to species, we present trends for Alder Flycatchers for 1973–91, rather than for 1968–91 as with other species in SOQ; Willow Flycatchers were too few there for analysis.

Table 1
Numbers of routes completed in the Breeding Bird Survey, Canada, 1984–91, and total numbers ever surveyed, by province or territory

Province or territory	No. of routes surveyed[a]								Total no. of routes
	1984	1985	1986	1987	1988	1989	1990	1991	
Newfoundland	24	2	3	4	1	1	1	2	29
Prince Edward Island	4	4	4	2	2	2	2	2	4
Nova Scotia	12	12	11	13	12	11	11	13	24
New Brunswick	16	18	13	17	14	13	11	15	29
Quebec	30	29	24	24	25	26	40	31	84
Ontario	50	44	49	51	51	48	45	53	81
Manitoba	15	13	17	17	12	29	31	33	41
Saskatchewan	14	16	14	22	16	26	26	27	63
Alberta	24	30	24	32	31	40	42	48	74
British Columbia	36	35	33	31	36	41	44	47	93
Yukon	0	0	9	13	8	9	7	13	24
Northwest Territories (Mackenzie district)	0	0	0	1	2	6	6	5	7
Total	225	203	201	227	210	252	266	289	548

[a] The largest numbers of routes surveyed in each province in one year are underlined. Largest numbers in years preceding 1984 are as follows:
P.E.I., 4 routes also in 1967–69, 1973–75, 1977–78, 1982
N.S., 23 routes in 1972
N.B., 24 routes in 1971–72
Que., 41 routes in 1979–80
Ont., 65 routes in 1976
Sask., 28 routes in 1973
B.C., 53 routes in 1974

In SBC, the analysis period began in 1973, and the combined data (from very few routes) in earlier years were not used; only Willow Flycatchers were analyzed, as Alder Flycatchers were scarce there.

Changes between years

The changes in bird numbers between 1990 and 1991 for 158 species analyzed in one or more regions are summarized for all regions in Table 2. Annual changes between 1988 and 1989 and between 1989 and 1990 are not shown in this report, although some of those changes are mentioned in the Discussion; those data are available on request (from BTC). Species analyzed but not included in Tables 2 and 3 are listed in a footnote to those tables; data on changes in these species may be requested (from BTC). The multiregion format for these tables facilitates comparisons between regions, but it does not show various numbers used in statistical validation of data, such as sample sizes and confidence intervals; these numbers are available upon request (from BTC). Year-to-year changes based on fewer than five routes in one region are not shown, and others based on 5–14 routes in a region are enclosed in parentheses.

Increases and decreases occurred in roughly equal numbers in 1988–89 and in 1989–90. In contrast, decreases were relatively more numerous than increases in 1990–91, mainly in the three eastern regions; this might reflect a temporary change—for example, high temperature or low precipitation—across those regions but has not yet been explored. Overall, 10–15% of the changes from one year to the next attained statistical significance, and another 5–10% approached that level. About 60% of the changes in one year were reversed in direction in the following year (increases following decreases, or vice versa); the remainder continued to increase or decrease. About 15% showed changes in the same direction (all upward, or all downward) in each of the last three years (1988–89, 1989–90, and 1990–91), often without any of the changes being statistically significant.

Long-term trends

The long-term trends calculated through 1991 for the 158 species listed in Table 2 are summarized in Table 3, with the years used in analysis in each region contained in a footnote. As with Table 2, validating statistics may be obtained upon request. Trends in a species based on records in 15–19 routes in a region in all years combined are enclosed in parentheses, and those based on fewer than 15 routes are not presented here, although some were computed (mostly species also analyzed in other regions).

Long-term declines outnumbered increases in the two boreal regions (COQ, CPP), whereas nearly as many species increased as decreased in SOQ and SBC, and increases predominated in MAR and PRA. Statistically significant trends usually comprised 15–30% of trends in each region, except that few increases in PRA were significant. Most species that had shown significant long-term trends through 1988 (Erskine et al. 1990) showed similar trends continuing through 1991.

Discussion

Coverage

Since 1988, the number of BBS routes surveyed in Canada has increased markedly, with new record high numbers of surveys in both 1990 and 1991. Table 1 and Figure 1 show that the increases were mostly effected by adding second routes in southern degree-blocks in the

Table 2
Annual percent change in bird populations between 1990 and 1991, Breeding Bird Survey, Canada[a,b]

Species	Annual % change in region[c,d]					
	MAR	COQ	SOQ	PRA	CPP	SBC
Common Loon	(+12.9)	−2.3				(+32.5)
Pied-billed Grebe				(−1.8)	(+38.5)	
Horned Grebe				(+7.6)	(+8.6)	
American Bittern	(+52.5)	(−51 *)	(−48)	(−33)	(+79.8)	
Great Blue Heron	(+8.8)	+46.4	+4.3			(−3.3)
American Black Duck	(−63 *)	(−74)				
Mallard			−74 *	+30.1	−60	+28.8
Osprey	(−13)					
Northern Harrier				−17		
Swainson's Hawk				−0.3		
Red-tailed Hawk				+52.1 *	+12.7	−15
American Kestrel	(−23)	+22.9	−26	−43	−17	+6.8
Gray Partridge				−26		
Ring-necked Pheasant						(−0.3)
Blue Grouse[e]						
Ruffed Grouse	(−16)				(−20)	(+244 *)
Sora				−24	+20.2	
American Coot				+10.2	−18.1	
Killdeer	+86.3 *	−0.2	+0.8	+0.4	−13	−31
Willet				−5.0		
Spotted Sandpiper	(−28)	(+23.1)	(−13)		−2.7	−2.5
Marbled Godwit				−28		
Common Snipe	−42 n	−54 *	−24	+35.7	−10	−1.1
Wilson's Phalarope				(−16)		
Black Tern				+83.0	+56.0	
Rock Dove	(+82.6)	(+71.1)	−0.5	−12	−32 *	(−7.8)
Band-tailed Pigeon[e]						
Mourning Dove			−15	+23.6	+12.8	(+58.5)
Black-billed Cuckoo		+261 *	(+66.9)			
Great Horned Owl			(−65)	(+32.8)		
Short-eared Owl[e]						
Common Nighthawk				(+13.7)		(+31.2)
Chimney Swift	(−35)		+24.6			
Ruby-throated Hummingbird	(+37.2)		(−68 *)			
Rufous Hummingbird						+22.6
Belted Kingfisher	(−25)	+65.0 n	+14.6			(−19)
Yellow-bellied Sapsucker[f]	(−17)	−7.7	(−61 *)		−44 *	−23
Downy Woodpecker	+9.8	+22.3	−38	(−15)	(+34.3)	(−26)
Hairy Woodpecker	(+81.3)	+42.7	(−0.8)	(+57.9)	−14	+35.4
Northern Flicker[f]	−9.7	−12	−30	+3.6	+40.8 *	−11
Pileated Woodpecker			(+32.4)			−21
Olive-sided Flycatcher	(+14.4)	−31			−16	+12.9
Western Wood-Pewee				(−23)	+0.2	−9.6
Eastern Wood-Pewee	−5.9		+7.0			
Yellow-bellied Flycatcher	(−35 *)	(−20)				
Alder Flycatcher	−3.6	−12	−16.8	(−31)	+12.3	
Willow Flycatcher						−6.4
Least Flycatcher	+19.8	−22 *	−27	+23.3	−11	(−58)
Hammond's Flycatcher						−5.9
Dusky Flycatcher						+7.0
Western Flycatcher[e,f]						
Eastern Phoebe		−21	−17	(−7.8)	−16	
Great Crested Flycatcher			−26			
Western Kingbird				−7.7		
Eastern Kingbird	(−23)	−15	−7.7	−0.1	+0.3	(+122)

(continued)

Table 2 *(continued)*
Annual percent change in bird populations between 1990 and 1991, Breeding Bird Survey, Canada[a,b]

Species	Annual % change in region[c,d]					
	MAR	COQ	SOQ	PRA	CPP	SBC
Horned Lark			−4.5	−1.3	−17	
Purple Martin			(+8.8)			
Tree Swallow	−6.5	+9.1	+16.4	−16	+17.5	+26.6
Violet-green Swallow						+38.1
Northern Rough-winged Swallow			(−11)			−15
Bank Swallow	−31	(−38)	−7.4	(+18.6)	−79 *	(+17.3)
Cliff Swallow	−7.8	+10.4	+15.2	+11.9	−31	−5.7
Barn Swallow	−9.6	−13	+0.7	0.0	−0.9	−19
Gray Jay	(−31)	(−57)			(−3.3)	(+97.2)
Steller's Jay						(+29.4)
Blue Jay	+36.5	−34	−13		−25	
Black-billed Magpie				−14 *	−1.4	(+20)
American Crow	−6.0	+1.5	−9.5	+8.8	−1.1	+1.8
Northwestern Crow						(−18)
Common Raven	+72.7	−7.5			+33	−0.4
Black-capped Chickadee	−31	−2.7	−38 *		+81.0 *	−28 n
Mountain Chickadee						−26
Boreal Chickadee	(−23)	(−29)				
Chestnut-backed Chickadee						(−46)
Red-breasted Nuthatch	−27	−20				−28
House Wren			−15	+43.6 *	+41.9 *	
Winter Wren	−6.9	+18.5 n				−50 *
Marsh Wren				(+173 *)		
Golden-crowned Kinglet	−28	(+21.3)				−53 *
Ruby-crowned Kinglet	−7.7	−14			−10	−0.4
Eastern Bluebird			(+14.1)			
Mountain Bluebird				(+18.3)	(−28)	(−44)
Veery	+4.4	−3.0	−20	(+47.2)	+3.3	(+39.0 n)
Swainson's Thrush	+5.6	+20.9			+6.7	+1.4
Hermit Thrush	−21 n	+16.5	(−21)		−15	(−15)
Wood Thrush			−37			
American Robin	−0.9	−2.2	−2.3	+31.6 *	+17.5 *	−13
Varied Thrush						−15
Gray Catbird	−3.2		−27	−6.6	−30	
Brown Thrasher			−31	+68.6 n		
Sprague's Pipit				(+70.6 n)		
Cedar Waxwing	+2.0	−11	−38 *	−56	+5.5	+9.3
Loggerhead Shrike				(+1.5)		
European Starling	−2.1	−1.2	−15	−11	−26	+22.7
Solitary Vireo	+37.0	(−29)				+10.0
Warbling Vireo			−6.1	−9.6	+3.0	+20.8
Red-eyed Vireo	+8.3	−1.3	−2.5	+1.3	−4.2	−3.4
Tennessee Warbler	+0.6	(−34)			(−25)	
Orange-crowned Warbler						+0.5
Nashville Warbler	+3.2	+0.4				
Northern Parula	−7.4					
Yellow Warbler	−21 *	−4.7	−28 *	+0.4	−5.4	+7.9
Chestnut-sided Warbler	−12	−19 *	+10.5		(−3.3)	
Magnolia Warbler	−6.6	−25 n				
Cape May Warbler	(−16)	(−63 *)				

(continued)

Table 2 *(continued)*
Annual percent change in bird populations between 1990 and 1991, Breeding Bird Survey, Canada[a,b]

Species	Annual % change in region[c,d]					
	MAR	COQ	SOQ	PRA	CPP	SBC
Black-throated Blue Warbler	(−58 *)	−33 n				
Yellow-rumped Warbler[f]	+2.6	+12.8			−23 *	+12.4
Townsend's Warbler						(+21.6)
Black-throated Green Warbler	−1.7	+16.4				
Blackburnian Warbler	+0.6	−10				
Bay-breasted Warbler	(+18.2 n)	(−54)				
Black-and-white Warbler	−25	−15 n	−31			
American Redstart	−8.8	−4.2	−29		(−8.0)	(−2.1)
Ovenbird	−18 *	−9.2 n	−8.5			
Northern Waterthrush	(−7.8)	−34 n	(+29.4)		(+54.6)	+3.1
Mourning Warbler	(−24)	+14.0	+1.2		(+7.3)	
MacGillivray's Warbler						+36.5 *
Common Yellowthroat	−9.4	−12 n	−5.7	+11.5	+17.2	+8.3
Wilson's Warbler						−14
Canada Warbler	(−38 *)	−7.9				
Scarlet Tanager			−50			
Western Tanager						+22.1 n
Rose-breasted Grosbeak	−25	+10.2	−21		+1.0	
Indigo Bunting			−17			
Rufous-sided Towhee			(−39)			(+3.3)
Chipping Sparrow	−11	−8.4	−16	−3.5	+34.0 *	−6.4
Clay-colored Sparrow				+17.5 *	−0.4	
Field Sparrow			(−55 *)			
Vesper Sparrow			−16	+10.5	+34.4	(+22.8)
Lark Bunting[e]						
Savannah Sparrow	−7.2	+9.9	−18 n	+20.9	−9.7	+7.5
Baird's Sparrow				(+62.7 *)		
Grasshopper Sparrow			(−41)			
Le Conte's Sparrow				(+103)	−0.6	
Song Sparrow	+28.4	−15 n	−17 *	+8.6	−8.9	−1.5
Lincoln's Sparrow	(−4.0)	(−19)			+17.4	(+63.1 *)
Swamp Sparrow	(−32 n)	+11.8	−47 n		(+193)	
White-throated Sparrow	−7.5	−6.5	−20		0.0	
White-crowned Sparrow						−8.9
Dark-eyed Junco[f]	+4.9	+0.6	(+116)		−11	−20 n
Chestnut-collared Longspur				(+0.4)		
Bobolink	−5.0	+25.9 n	+2.0	+29.4		
Red-winged Blackbird	−29 *	+9.1	−1.1	+9.8	−5.8	+130
Eastern Meadowlark			−3.0			
Western Meadowlark				+10.0	−5.1	(+14.3)
Yellow-headed Blackbird				−11	−45	
Rusty Blackbird		(−6.8)				
Brewer's Blackbird				+19.9	+10.0	+28.5
Common Grackle	+2.9	−16	+4.3	+67.2	−45 n	
Brown-headed Cowbird	−41 *	−32 *	−21	+21.8 *	+5.1	−1.9
Northern Oriole			−28 n	+0.8	−6.8	
Purple Finch	+37.9	−26	(−28)		(−44)	(−34)
House Finch						(+50.0)
Red Crossbill						−59
Pine Siskin	(+15.8)	(−80)			−55 *	−42 *

(continued)

Table 2 *(concluded)*
Annual percent change in bird populations between 1990 and 1991, Breeding Bird Survey, Canada[a,b]

Species	Annual % change in region[c,d]					
	MAR	COQ	SOQ	PRA	CPP	SBC
American Goldfinch	−28	−37 n	−21	−20 n	+2.8	(+2.4)
Evening Grosbeak	(−2.6)	+501 n				−23
House Sparrow	−14	(+20.4)	−9.2	−21 *	−4.0	(−18)

[a] Regions and analysis periods:

Maritime provinces (MAR)	1966–91
Central Ontario and central Quebec (COQ)	1969–91
Southern Ontario and southern Quebec (SOQ)	1968–91[†]
Southern Prairie provinces (PRA)	1970–91
Central Prairie provinces (CPP)	1971–91
Southern British Columbia (SBC)	1973–91

[†] Except Alder Flycatcher 1973–91 (see text).

[b] Other species analyzed but not included in table:

MAR (1)	Herring Gull
COQ (1)	Herring Gull
SOQ (1)	Ring-billed Gull
PRA (11)	Green-winged Teal, Northern Pintail, Blue-winged Teal, Northern Shoveler, Gadwall, American Wigeon, Redhead, Canvasback, Lesser Scaup, Franklin's Gull, Ring-billed Gull
CPP (7)	Green-winged Teal, Northern Pintail, Blue-winged Teal, Northern Shoveler, American Wigeon, Lesser Scaup, Franklin's Gull
SBC (3)	Canada Goose, Common Merganser, Glaucous-winged Gull

Note: BBS data for gulls and most waterfowl do not provide representative trends in numbers of these species, which are more effectively monitored by other surveys.

[c] Statistical significance: *, $P < 0.05$; n, $0.05 < P < 0.15$. The asterisk (*) means that a change is statistically significant; in other words, the probability (P) of such a trend occurring by chance is less than (<) 5% (0.05). The letter n (nearly significant) means that the probability of such a trend occurring by chance is less than 15%, except in those cases marked by an asterisk.
Trends shared by "adjoining" regions are underlined; adjoining regions are MAR with COQ, SOQ; COQ with SOQ, CPP; SOQ with PRA; CPP with PRA, SBC.

[d] Annual percent changes based on 5–14 routes in a region are enclosed in parentheses.

[e] Species with no data shown were analyzed, but the annual changes for these species were based on fewer than five routes each; cf. trends for these species in Table 3.

[f] Both or all forms combined.

Prairie provinces. As well, several previously unsampled blocks in central Manitoba had routes first surveyed in these years. Coverage in eastern Canada declined during the breeding bird atlas projects there (Ontario 1981–85, Quebec 1984–89, Maritimes 1986–90) and has not yet regained earlier levels, despite an impressive 10 new routes in Quebec in 1990. Few of the more remote northern routes in Ontario and Quebec have been surveyed since 1983. Coverage in the Yukon and Mackenzie district, Northwest Territories, since 1986 has been encouraging, but it is still too sparse to allow meaningful analyses of trends in the northern bird species for which these routes provide the only samples.

Many individual observers have provided long-term coverage of their routes, and their repeated surveys are the mainstay of our ability to monitor trends in bird numbers. Even though the route-regression approach allows us to use data for routes that are not surveyed every year, we still depend heavily on the same observers returning to their routes in later years. With the BBS now into its second quarter-century, we recognize that the enthusiasts who supported the project so well in its first decades must gradually be replaced by newcomers. Table 4 shows the observers who made more than 25 regular surveys in the BBS since it began in Canada in 1966; all these people ran two or more routes for many years. Their replacement is not a matter of choice. All of us are getting older; three observers listed in Table 4 withdrew from the BBS after 1989, and three others had retired earlier. It is hoped that the transition to new observers will be a gradual process, preferably with newcomers accompanying the veterans during one or more surveys before the latter retire from the BBS.

Year-to-year changes

As in earlier BBS analyses, we noted that an increase within a species in one year is followed, more often than not, by a decrease in the next year, or vice versa. This might be interpreted as indicating density-dependent population regulation—that is, high-density populations experience more competition for some limiting resource and thus survive (or breed) less successfully than low-density ones. Nowadays, with so many human actions affecting bird numbers regardless of whether the numbers are high or low in density, fewer people are convinced that density-dependent regulation is the usual state. Nevertheless, the fact that direction reversals outnumbered sustained changes in either direction in all regions in both recent comparisons (1988–89 vs. 1989–90, and 1989–90 vs. 1990–91) suggests that the prevalence of direction reversals in Canadian songbird trends is not a statistical artifact.

Many statistically significant and nearly significant changes observed were only more abrupt oscillations around population levels somewhere between the highest and lowest noted in earlier years. Some may be explained plausibly by correlations with environmental factors, but others lack obvious explanations. For example, in MAR between 1988 and 1989, the significant increase in Red-breasted Nuthatches correlated well with the increased

Table 3
Long-term trends in mean annual percent change in bird populations between 1966 and 1991, Breeding Bird Survey, Canada[a,b]

Species	Long-term trend in region[c,d]					
	MAR	COQ	SOQ	PRA	CPP	SBC
Common Loon	+4.5*	+2.8				+4.4*
Pied-billed Grebe				−2.0	−6.1	
Horned Grebe				−8.4	−1.0	
American Bittern	−2.2	+2.4	+0.3	−8.3*	−7.9*	
Great Blue Heron	+2.0	+2.9	+4.0*			−1.4
American Black Duck	+1.3	−4.0				
Mallard			+6.8*	+1.1	−2.5	−1.3
Osprey	+3.6*					
Northern Harrier				−1.3		
Swainson's Hawk				+3.5		
Red-tailed Hawk				+2.2	+2.2	+6.1*
American Kestrel	+3.0n	+2.9	+0.6	+5.8	−0.2	+2.8*
Gray Partridge				−0.7		
Ring-necked Pheasant						−3.6n
Blue Grouse						−3.6
Ruffed Grouse	−0.9				−6.1*	−5.0*
Sora				−3.4	−2.4n	
American Coot				−0.4	−2.9n	
Killdeer	+8.4*	−3.0n	−0.2	−4.3*	−5.0*	−2.4
Willet				+0.3		
Spotted Sandpiper	+1.6	−1.2	−4.4*		−1.9	+0.9
Marbled Godwit				+0.6		
Common Snipe	−0.5	−2.7*	−1.4	−5.7	−0.9	+1.0
Wilson's Phalarope				+3.0		
Black Tern				−2.6	−4.9n	
Rock Dove	+2.5	+8.5	+2.0	−1.7	+3.3	−0.9
Band-tailed Pigeon						−3.8n
Mourning Dove			+3.5*	+2.2n	+1.1	−3.5
Black-billed Cuckoo		+29.5	−3.1			
Great Horned Owl			−2.0	+2.5		
Short-eared Owl				−3.2		
Common Nighthawk				+3.9n		−2.4
Chimney Swift	−1.2		−5.0*			
Ruby-throated Hummingbird	−1.1		−0.1			
Rufous Hummingbird						−2.8
Belted Kingfisher	+1.9	−2.7n	−0.3			+0.5
Yellow-bellied Sapsucker[e]	−1.8	+0.2	−1.0		−5.3*	−1.4
Downy Woodpecker	+7.0*	+3.0*	+0.2	+1.8	−1.2	+1.2
Hairy Woodpecker	+4.6	−0.3	−0.3	+0.7	−0.1	+1.3
Northern Flicker[e]	+1.0	−1.1	−3.4*	−6.2*	−2.2*	−1.4
Pileated Woodpecker			+0.9			+3.7
Olive-sided Flycatcher	−1.3	−2.2			+4.0	−4.0*
Western Wood-Pewee				(+1.1)	+8.2*	−1.7*
Eastern Wood-Pewee	+0.1		−1.5n			
Yellow-bellied Flycatcher	+2.1n	+2.6				
Alder Flycatcher	+2.0*	+2.6*	+4.8*	+5.4	+1.0	
Willow Flycatcher						−0.3
Least Flycatcher	−3.9	−2.2*	−1.2	+5.1*	+2.2*	−3.4
Hammond's Flycatcher						+4.1
Dusky Flycatcher						+4.3
Western Flycatcher[e]						−5.7
Eastern Phoebe		−3.1*	−2.8*	−3.7	−3.1	
Great Crested Flycatcher			−1.1			
Western Kingbird				+3.3		
Eastern Kingbird	+2.4	+0.7	+1.4	+0.6	−0.3	−1.6

(continued)

Table 3 *(continued)*
Long-term trends in mean annual percent change in bird populations between 1966 and 1991, Breeding Bird Survey, Canada[a,b]

Species	Long-term trend in region[c,d]					
	MAR	COQ	SOQ	PRA	CPP	SBC
Horned Lark			−0.4	+0.3	−8.8*	
Purple Martin			+2.1			
Tree Swallow	−0.7	−2.5	+2.4	+0.8	+2.0	+2.3 n
Violet-green Swallow						+4.2
Northern Rough-winged Swallow			−1.1			+2.8
Bank Swallow	+14.4	−11	−2.5	−1.4	−4.4	+0.2
Cliff Swallow	+1.6	+0.5	−3.4 n	−0.2	+0.1	+1.9
Barn Swallow	−1.2	−3.2*	−1.0	−0.3	+0.5	−1.1
Gray Jay	+0.4	−1.0			−7.6	−0.1
Steller's Jay						+3.4
Blue Jay	+1.4	−2.1*	+3.8*		+0.4	
Black-billed Magpie				+0.1	−0.2	−1.2
American Crow	+2.0*	+0.4	+0.5	−1.9*	−1.4	+0.1
Northwestern Crow						(+1.2)
Common Raven	+4.1*	+4.7*			+0.1	+4.1 n
Black-capped Chickadee	+5.0*	+1.3	+6.2*		−0.8	−2.7*
Mountain Chickadee						+2.6
Boreal Chickadee	−4.2*	−4.9*				
Chestnut-backed Chickadee						+1.3
Red-breasted Nuthatch	+5.1*	+1.7				+4.7*
House Wren			−1.0	+2.6*	+1.9*	
Winter Wren	−0.8	+1.7				+1.7
Marsh Wren				+5.7		
Golden-crowned Kinglet	+10.3*	+0.9				+0.4
Ruby-crowned Kinglet	−1.6	−2.6*			+10.1	−1.5
Eastern Bluebird			+0.3			
Mountain Bluebird				−4.2	+0.1	−5.7*
Veery	+1.6	−1.1	−1.2	(+0.4)	−4.5	+0.2
Swainson's Thrush	0.0	0.0			+4.4	−1.5
Hermit Thrush	+3.7 n	+4.0*	+3.0		−0.2	+1.0
Wood Thrush			−1.1			
American Robin	0.0	+0.9 n	+0.9	+4.1*	+1.3*	−0.8
Varied Thrush						−3.0
Gray Catbird	+0.7		−2.9	+0.5	−2.8*	
Brown Thrasher			−5.6*	+1.4		
Sprague's Pipit				−0.5		
Cedar Waxwing	+7.5*	+0.4	+4.4*	+1.9	0.0	+2.3
Loggerhead Shrike				−8.2*		
European Starling	−1.5	−3.2*	−1.4*	+6.0	−0.5	−3.0 n
Solitary Vireo	+8.7*	+1.4				+5.1*
Warbling Vireo			+3.6	+3.4	+1.7	+4.1*
Red-eyed Vireo	+3.5*	+1.5*	+0.4	+2.0	+2.0*	−2.6*
Tennessee Warbler	+5.8	−12			+4.6	
Orange-crowned Warbler						+1.9
Nashville Warbler	−1.0	−4.5				
Northern Parula	+3.1	+1.7				
Yellow Warbler	+2.5*	+1.6	+0.9	+0.3	+2.2*	−3.3*
Chestnut-sided Warbler	−0.8	−0.4	+3.0 n		−1.0	
Magnolia Warbler	+0.9	+2.3				
Cape May Warbler	+2.1	+4.0				

(continued)

Table 3 *(continued)*
Long-term trends in mean annual percent change in bird populations between 1966 and 1991, Breeding Bird Survey, Canada[a,b]

Species	Long-term trend in region[c,d]					
	MAR	COQ	SOQ	PRA	CPP	SBC
Black-throated Blue Warbler	+0.9	−0.9				
Yellow-rumped Warbler[e]	+3.3*	−4.3			+1.0	+2.9
Townsend's Warbler						+1.3
Black-throated Green Warbler	−0.2	+0.2				
Blackburnian Warbler	+6.9*	+1.4				
Bay-breasted Warbler	+8.3	−5.8				
Black-and-white Warbler	+0.9	+1.1	+6.4*			
American Redstart	+1.2n	−3.5n	−1.9		−3.5	+1.3
Ovenbird	+0.8	+0.4	+2.9*			
Northern Waterthrush	+0.9	−3.1	−1.6		+3.2	+7.0n
Mourning Warbler	+0.2	+0.7	+5.5*		−2.9*	
MacGillivray's Warbler						−3.2
Common Yellowthroat	−1.0	−2.9*	+0.4	+3.0n	−2.8n	+0.6
Wilson's Warbler						−0.9
Canada Warbler	+2.3	−3.0	−1.3			
Scarlet Tanager			−0.5			
Western Tanager						+0.7
Rose-breasted Grosbeak	+4.3*	−4.9*	−0.3		−0.4	
Indigo Bunting			+1.6			
Rufous-sided Towhee			−3.2*			+1.7
Chipping Sparrow	−0.5	−0.2	+1.1	+4.2	−4.6*	−2.7
Clay-colored Sparrow				+0.7	−2.7*	
Field Sparrow			+0.2			
Vesper Sparrow			−2.3	+2.7*	+0.4	−2.1
Lark Bunting				+31.5		
Savannah Sparrow	−3.4*	−0.9	−2.0*	+2.3	+1.1	+0.1
Baird's Sparrow				+4.3		
Grasshopper Sparrow			−0.4			
Le Conte's Sparrow				−3.9	+4.0	
Song Sparrow	−2.2*	−2.7*	+0.5	−1.3	−4.1*	−0.8
Lincoln's Sparrow	+4.1	+5.2			+20.2n	+11.2*
Swamp Sparrow	−1.2	−1.7	+5.7		−6.3	
White-throated Sparrow	−3.6*	−1.8*	+0.3		−0.6	
White-crowned Sparrow						−1.9
Dark-eyed Junco[e]	−0.1	−2.3	(+0.5)		+3.3	−1.1
Chestnut-collared Longspur				−0.7		
Bobolink	+1.4	−0.1	−3.0n	+3.1		
Red-winged Blackbird	−1.9	−2.0n	−0.8	−2.2*	+1.0	+0.8
Eastern Meadowlark			−4.4*			
Western Meadowlark				−1.9*	−3.2*	−0.8
Yellow-headed Blackbird				+10.3n	+4.7	
Rusty Blackbird	−4.2	−0.4				
Brewer's Blackbird				+1.3	−2.0*	+2.7
Common Grackle	−2.1*	−2.3n	−2.5*	−2.7	−1.5	
Brown-headed Cowbird	−6.4*	−7.3*	−4.5*	+1.0	−2.4	−1.4
Northern Oriole			−2.1	+3.3*	+2.0n	
Purple Finch	−2.0	−4.0*	+3.2n		−4.4	−0.2
House Finch						+7.0*
Red Crossbill						+2.3
Pine Siskin	+2.0	−1.6			−14n	−3.8*

(continued)

Table 3 *(concluded)*
Long-term trends in mean annual percent change in bird populations between 1966 and 1991, Breeding Bird Survey, Canada[a,b]

Species	Long-term trend in region[c,d]					
	MAR	COQ	SOQ	PRA	CPP	SBC
American Goldfinch	−0.8	−4.2 *	−1.1 n	+2.4	+2.2 n	−2.5
Evening Grosbeak	+8.3	−23 n				−7.6
House Sparrow	−4.7 *	−7.7 *	−1.3	−0.1	−3.8 *	−3.0

[a] Regions and analysis periods:

Maritime provinces (MAR)	1966–91
Central Ontario and central Quebec (COQ)	1969–91
Southern Ontario and southern Quebec (SOQ)	1968–91[1]
Southern Prairie provinces (PRA)	1970–91
Central Prairie provinces (CPP)	1971–91
Southern British Columbia (SBC)	1973–91

[1] Except Alder Flycatcher 1973–91 (see text).

[b] Other species analyzed but not included in table:

MAR (1)	Herring Gull
COQ (1)	Herring Gull
SOQ (1)	Ring-billed Gull
PRA (11)	Green-winged Teal, Northern Pintail, Blue-winged Teal, Northern Shoveler, Gadwall, American Wigeon, Redhead, Canvasback, Lesser Scaup, Franklin's Gull, Ring-billed Gull
CPP (7)	Green-winged Teal, Northern Pintail, Blue-winged Teal, Northern Shoveler, American Wigeon, Lesser Scaup, Franklin's Gull
SBC (3)	Canada Goose, Common Merganser, Glaucous-winged Gull

Note: BBS data for gulls and most waterfowl do not provide representative trends in numbers of these species, which are more effectively monitored by other surveys.

[c] Statistical significance: *, $P < 0.05$; n, $0.05 < P < 0.15$. The asterisk (*) means that a change is statistically significant; in other words, the probability (P) of such a trend occurring by chance is less than (<) 5% (0.05). The letter n (nearly significant) means that the probability of such a trend occurring by chance is less than 15%, except in those cases marked by an asterisk.
Trends shared by "adjoining" regions are underlined; adjoining regions are MAR with COQ, SOQ; COQ with SOQ, CPP; SOQ with PRA; CPP with PRA, SBC.

[d] Trends based on records in 15–19 routes in a region in all years combined are enclosed in parentheses.

[e] Both or all forms combined.

availability of food in the huge cone crop on spruces and firs in 1988; these birds were also found in record numbers on Christmas Bird Counts in the Maritimes in 1988. Golden-crowned Kinglets there also showed both high numbers on Christmas Bird Counts in 1988 and statistically significant increases in the BBS in 1988–89, but no connection with the cone crop is obvious for these strictly insectivorous birds. It was not possible to explore all such correlations in this report, but we hope that interested bird students will make such correlations for the areas of Canada with which they are familiar and will publish their findings.

Other significant short-term changes seem to be parts of continuing upward or downward trends (discussed below). Examples include Common Snipe decreasing over both the short and long term in COQ, Killdeer decreasing widely (except in MAR), Least Flycatcher decreasing in COQ, House Wren increasing in PRA and CPP, Lincoln's Sparrow increasing in SBC, and Pine Siskin decreasing in CPP and SBC. The scarcity of statistically significant year-to-year changes that form parts of significant long-term trends probably has at least two causes: the year-to-year changes are based on smaller samples (only about 60% of the surveys run in any year, vs. 80+% for the long-term trends), so they are more likely to involve chance variations in either direction, rather than being parts of ongoing trends; and some significant year-to-year changes may reflect drastic short-term variations in particular environmental factors that will be reversed in the next year, whereas long-term trends arise from continuing, but not often drastic, perturbations in the various environments (not all in Canada) on which a species depends through its yearly cycle. Both short- and long-term changes deserve study, but continuing changes are more likely to reflect threats for the birds.

Long-term trends

Methodology. The route-regression approach (Geissler and Noon 1981) was introduced to avoid the risk of extreme random variations, which may occur when year-to-year changes are "chained together" over longer periods. The route-regression programs as originally developed in both the United States and Canada produced many long-term trends, which, extrapolated over periods of more than 20 years, indicated many quite improbably large changes in species populations. For this reason, our earlier report (Erskine et al. 1990) and some U.S. Fish and Wildlife Service (USFWS) BBS reports showed only the directions of trends and their statistical significance. Recent modifications to the statistical weighting procedure used in Canada, as described above under Data analysis, seem to have alleviated this problem, although a few changes in each region still seem intuitively improbable. With the present numbers of analyses, 3–5 erroneous "statistically significant changes" can be expected to appear by chance in each Canadian region each year.

Further developmental work is still needed to allow computation and presentation of annual indices to the bird populations tracked by these long-term trends. Few trends continue monotonously upward or downward throughout a 25-year period; for example, Red-winged Blackbirds

Table 4
Observers with 25 or more surveys of Breeding Bird Survey routes in Canada, not including surveys where another person was the principal observer, supplementary surveys, or surveys of nonrandom routes

Observer	Total surveys	Years	Province(s)
David Christie	87	1966–91	N.B.
Anthony Erskine	84[a]	1966–89	B.C., Alta., Sask., Man., Ont., Que., N.B., N.S., P.E.I.
Herbert Copland	69	1967–89	Man.
Murray Speirs	64	1968–83	Ont.
Kenneth Johnson	57[a]	1976–87	Sask., Man.
Wayne Neily	53	1966–91	Yukon, Man., N.S.
James Grant	50	1968–83	B.C.
Mabel McIntosh	47	1966–91	Que.
Jack Park	47	1968–91	Alta.
Christopher Helleiner	46	1967–89	N.S.
Clifford McFayden	45	1969–91	Ont.
Willis Hall	42	1970–91	Alta.
Helen Inch	42	1968–91	Ont.
Ronald Lepage	42	1967–91	Que.
Maurice Mareschal	42	1970–91	Sask.
Graeme Greenlee	41	1970–91	Alta.
Gary Davidson	40	1974–91	B.C.
Reginald Ouellet	38	1969–91	Que.
Jean Wallace	33	1972–91	Ont.
Madelon Schouten	32	1973–91	B.C.
Wayne Weber	31	1974–90	B.C., Alta.
Danny Lee	29	1977–91	Ont.
Richard Howie	26	1976–91	B.C.
Diane Weismiller	26	1972–91	B.C.
Stefan Jungkind	25	1981–91	Alta.

[a] Also one (AE) or several (KJ) surveys in the United States.

increased consistently east of the Rockies through the first 10 years of the BBS (Erskine 1978, Fig. 11), but since then their trend has been as uniformly downward, such that extrapolated numbers in four of the five regions are now lower than at the start of the BBS. Determining where to divide the data into periods that provide meaningful trends is a difficult problem, requiring detailed examination of the data for each species.

Areas of concern. (1) Neotropical migrants. Concern over apparent declines in forest birds that breed in the United States and winter in Latin America (Robbins et al. 1989) sparked a major interagency program (Partners in Flight) in the United States and discussion of a parallel program in Canada. We have not yet duplicated the USFWS BBS analyses that, with other data, triggered those initiatives. Some trends from BBS data listed by Robbins et al. (1989) may have been inflated by the statistical weighting procedure they used. Our analyses do not indicate this as the area of greatest concern involving forest birds in Canada. Statistically significant long-term declines involving neotropical migrants breeding in Canada are few (Table 3: MAR—Alder Flycatcher; COQ—Barn Swallow, Common Yellowthroat, Rose-breasted Grosbeak; SOQ—Spotted Sandpiper, Chimney Swift; CPP—Gray Catbird, Mourning Warbler; SBC—Olive-sided Flycatcher, Western Wood-Pewee, Red-eyed Vireo, Yellow Warbler). None of these showed significant parallel declines in adjacent regions, and this number of apparent changes could occur by chance. Significant increases seem to be both more frequent and more widespread than decreases among this group of birds in Canada.

(2) Common "edge" and open-country species that winter in the United States. The downward trends in many of these birds, often spanning several eastern regions, continued over the last three years (cf. Erskine et al. 1990). Such declining species (Table 3) include Killdeer, Northern Flicker, Eastern Phoebe, European Starling, Savannah Sparrow, Song Sparrow, White-throated Sparrow, Red-winged Blackbird, Eastern and Western meadowlarks, Rusty Blackbird, Common Grackle, Brown-headed Cowbird, American Goldfinch, and House Sparrow, some of which are the most familiar birds in areas settled by people, although most must have been much scarcer before European settlement, when eastern North America was largely forested.

(3) Impacts of forestry in Canada. The 45 years since World War II have seen enormous growth in forest exploitation in this country, with systematic reforestation becoming widespread only since 1980. As a threat to forest birds, spraying of toxic chemicals against insect pests, especially spruce budworm *Choristoneura fumiferana*, was a concern from its start (e.g., Kendeigh 1947). Some major bird kills caused by pesticides used against budworm have been documented, the BBS contributing to the description of the bird kill caused by spraying with phosphamidon in New Brunswick in 1975 (Pearce et al. 1976). The effects of forest cutting attracted less general attention until the 1980s, when the huge extent of habitat loss in all forest regions became apparent. Some significant changes measured by the BBS correlate with habitat changes resulting from the interactions of spruce budworm and forestry practices in MAR—for example, the decline of Boreal Chickadees (also in COQ?) and increase of Rose-breasted Grosbeaks, both presumably arising from the loss of continuous conifer stands and their replacement by young mixed conifer-hardwood cover. No other significant trends observed seem obviously correlated with major changes in forest habitats, perhaps because much of the widespread forest cutting has occurred north of the areas well sampled by the BBS in Canada. The significant long-term increases in several forest bird populations in MAR—for example, Solitary and Red-eyed vireos, Yellow-rumped and Blackburnian warblers—may still reflect recovery from numbers depressed by DDT spraying of forests in 1952–67; such recovery was probably complete before 1980, but it could still influence the overall long-term trends if not masked by subsequent declines. Examination of the trends over shorter periods is needed to clarify that situation.

Conclusions

This progress report follows the form of earlier BBS summaries in this series. We hope it will also achieve our intention of providing published feedback to observers before the following BBS season begins, to encourage future efforts. Many desirable manipulations of BBS data suggested in the past were not completed in time for inclusion here; we still plan to pursue them. With the data sets now spanning 18–25 years in the major regions, examination of shorter periods is increasingly necessary for any

determination of factors causing trends. However, with the larger numbers of species now analyzed, automation of both the analyses and the examination of results is essential to focus attention on meaningful changes, rather than on the manipulation of data.

Canadian BBS coverage continued to grow in the last three years, reaching new record levels (289 routes run in 1991). The increase was mainly in settled areas, and there was little gain in northern parts of most provinces; coverage in the territories, however, was the best ever.

Year-by-year comparisons need to be examined each year for correlations with potential causative factors. The annual changes detected herein produced unpredictably large or small effects on the long-term trends to which they contributed. Analysis procedures are not yet ideal for all our purposes.

The long-term trends showed relatively little change from those reported for the same species through 1988. Of the 172 species analyzed, 81–92 in each region, we present trend data for 158 species. The lack of obvious declines in neotropical migrants and the decreases in common land birds that winter in the eastern United States remained conspicuous in our results. Relatively few long-term trends showed obvious correlations with habitat changes resulting from forestry practices in Canada.

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